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Low-Luminosity AGNs and Unification

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Abstract. More than one third of all nearby galaxies show indications of low-luminosity nuclear activity. These low-luminosity AGNs (LLAGNs) are traditionally classified into a variety of categories depending on their forbidden-line ratios and on the presence or absence of broad-line emission. By analogy with Seyfert unification models, it is natural to ask whether the various LLAGN types are different manifestations of the same underlying phenomenon, with observed differences being solely due to orientation and obscuration, or whether there are fundamentally distinct physical processes at work in different categories of LLAGNs. This contribution reviews some recent observations of LLAGNs in the context of AGN unification scenarios.

1. Introduction

During the past two decades, unification models have been remarkably successful at clarifying the underlying connections between a variety of types of AGNs, including Type 1 and 2 Seyferts, radio galaxies and quasars (Antonucci 1993). These unification scenarios attempt to explain the differences between certain AGN classes as the result of varying orientation to our line of sight of the central engine and an "obscuring torus" that surrounds it. This review explores the question of whether similar unification ideas can also be applied to low-luminosity AGNs (LLAGNs), which make up the vast majority of the AGN population. These include low-luminosity Seyferts, low-ionization nuclear emission-line regions (LINERs), and transition-type objects with properties intermediate between those of LINERs and those of normal H II nuclei.

Unification studies of Seyfert galaxies are primarily concerned with figuring out whether Seyfert 2s are intrinsically the same kind of AGNs as Seyfert 1s. For LINERs, the unification question takes on a somewhat different focus, because it is not clear whether all of the Type 2 LINERs and transition objects are genuine AGNs at all. Ultimately, we may be able to achieve a partial unification in which some Type 2 objects are shown to be obscured or very faint accretion-powered sources, while others may prove to be completely unrelated to the AGN phenomenon. This has important ramifications for AGN demographics, because the population of LINER 2s and transition objects outnumbers all other types of AGNs combined. The fraction of galaxies containing genuine AGNs also sets a lower limit to the fraction of galaxies containing supermassive black holes. This is still a pertinent issue because dynamical measurements of black hole

masses have been performed only for a few dozen galaxies, while AGN surveys can indirectly detect black holes in vastly more galaxies, and over a broader range of Hubble types.

In applying unification ideas to LLAGNs, several questions arise. To what extent is our view of LLAGNs determined by orientation and obscuration? Do Type 2 LLAGNs show evidence for obscuring tori in the form of polarized broad-line emission, heavily absorbed X-ray sources, or ionization cones? And are some objects classified as LLAGNs actually powered predominantly or entirely by stellar processes, rather than by accretion?

Other aspects of the LLAGN phenomenon will be covered in more detail in other contributions to this volume, including those by Nagar (radio observations), Mushotzky (X-ray observations), and Ho (spectral energy distributions and central engine physics). Additional recent reviews of the properties of LLAGNs, including discussion of unification issues, are given by Véron-Cetty & Véron (2000) and by Ho (2002).

2. LLAGN Classification and Demographics

2.1. Optical Classification of LLAGNs

The most complete and comprehensive surveys for nearby AGNs have been carried out in the optical, and emission-line nuclei are classified into a few general categories based on their forbidden-line ratios. The basic categories include H II nuclei (i.e., nuclei whose emission lines are predominantly powered by young, massive stars), Seyferts, and LINERs. Heckman (1980) first defined LINERs as galaxies whose spectra satisfy [O II] $\lambda3727$ / [O III] $\lambda5007 \geq 1$ and [O I] $\lambda6300$ / [O III] $\lambda5007 \geq 1/3$. Other authors have often used equivalent classifications based on [O I]/Hα and [O III]/Hβ, since these ratios are less sensitive to reddening. The exact cutoff between LINERs and Seyferts is essentially arbitrary, however. There is also a category of "transition-type" nuclei, whose emission-line ratios are intermediate between those of H II regions and LINERs. Transition nuclei are sometimes referred to as weak-[O I] LINERs (Filippenko & Terlevich 1992), because their spectra differ from LINERs mainly in that their [O I] $\lambda6300$ emission is too weak to meet the LINER classification criteria.

Low-ionization nebulae satisfying the LINER definition occur in a variety of environments, including the nuclei of predominantly early-type (E–Sb) galaxies, superwind galaxies, filaments of gas in cooling flows, and some ULIRGs. The focus of this review will be on the first category: nearby galaxies with low-ionization emission in the inner $r \lesssim 200$ pc. These LINERs typically have bolometric luminosities of $\lesssim 10^{42}$ erg^{-1} s^{-1} (Ho 1999), so they are orders of magnitude less luminous than powerful Seyferts and QSOs. Many nearby radio galaxies such as M87 and M84 are LINERs, and in fact LINERs as a class appear to be radio-loud objects, even those in spiral host galaxies (Ho 1999). The survey of Ho et al. (1997a) found that 11% of nearby galaxies are Seyferts, 19% are LINERs, and 13% have LINER/H II transition nuclei. The transition nuclei are often considered to be a subset of the LINERs, although recent data suggests that they may be unrelated phenomena (see §5).

The low luminosity of these objects makes them difficult targets for observational study, even in very nearby galaxies. For example, it is essentially impossible to discern whether LINERs have nonstellar, featureless continua from ground-based observations, since their nuclear spectra are dominated by starlight from the surrounding galaxy bulge. The optical narrow emission lines of LINERs can be observed without much difficulty, but their interpretation has long been a source of controversy because the optical line ratios can be reproduced reasonably well by models based on a variety of different physical mechanisms, including shock heating (Dopita & Sutherland 1996), photoionization by a nonstellar continuum (Ferland & Netzer 1983; Halpern & Steiner 1983), or photoionization by hot stars (Shields 1992). Thus, it is important to look for other signs of nonstellar activity in these objects.

2.2. Broad Emission Lines in LLAGNs

Some recent reviews of AGN emission lines have categorically denied the very existence of broad emission lines in LINERs as a class (Krolik 1999; Sulentic, Marziani, & Dultzin-Hacyan 2000). However, there is no doubt that many LINERs do indeed have broad-line regions (BLRs); this section briefly reviews the evidence.

Following Heckman's pioneering survey, the detailed study of M81 by Peimbert & Torres-Peimbert (1981) and the spectroscopic surveys by Stauffer (1982), Keel (1983), and Filippenko & Sargent (1985) showed that in some objects the Hα line has a broad component or broad wings which are not present on the forbidden-line profiles, indicating that the broad emission originates in a physically distinct region. Detecting broad-line emission in LLAGNs is tricky, because the broad lines are faint and the [N II] $\lambda\lambda$6548, 6583 lines are superposed on the wings of Hα. (Broad Hβ would be a cleaner measurement since it is less contaminated by blending, but it is usually too faint to detect in ground-based spectra.) The underlying starlight continuum must be subtracted carefully prior to fitting the profiles, to remove the effects of stellar absorption features. Also, the stellar continua of galaxy bulges have a bump centered roughly around the Hα+[N II] blend which can be confused with broad-line emission if it is not subtracted properly.

The most comprehensive ground-based survey is that of Ho et al. (1997a,b). They performed decompositions of the Hα+[N II] blend using the [S II] lines as templates for the forbidden-line profiles. Overall, 20% of the LLAGNs required a broad component to fit the Hα emission, with a median FWHM of 2200 km s^{-1} and median luminosity of 10^{39} erg s^{-1}. The figure of 20% should be considered a lower limit, because of the difficulty of detecting very faint broad lines. If a similar survey were done with *HST* and a much narrower slit, it would most likely find a larger fraction of Type 1 objects. An intriguing recent development has been the discovery of extremely broad (FWZI $\approx 15,000 - 20,000$ km s^{-1}) double-peaked or double-shouldered Hα emission lines in several LINERs; see Ho et al. (2000) for a summary of their properties. From the number of double-peaked emitters detected so far (some of which have been transient features), the fraction of LINER 1s having double-peaked emission might be of order $\sim 10\%$, but the actual frequency is unknown. I have recently begun a ground-based

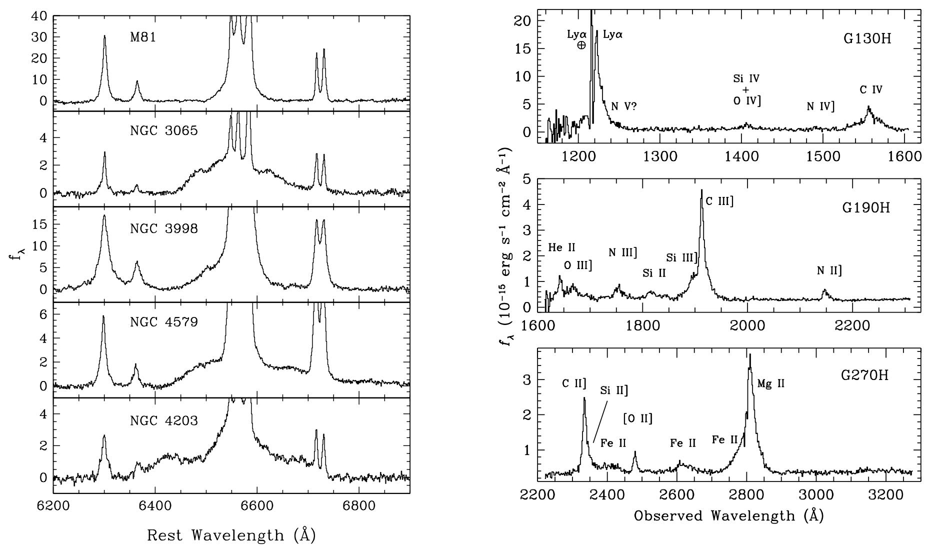

Figure 1. Examples of broad emission lines in LINERs. *Left:* Starlight-subtracted spectra of LINER 1s, obtained in March 2001 at the MMT Observatory. *Right: HST* UV spectrum of NGC 4579, from Barth et al. (1996), showing broad components of Lyα, C IV, C III, and Mg II.

spectroscopic survey of LINER 1s to try to address this question; the spectra of a few objects with unusual broad-line profiles are shown in Figure 1.

Ultraviolet (UV) spectra of a few LINER 1s have revealed additional broad emission lines, confirming the Type 1 classification of these objects. However, only a handful of LINER 1s have been observed spectroscopically in the UV, first with *IUE* (Peimbert & Torres-Peimbert 1981; Reichert et al. 1992) and later with *HST* (Ho et al. 1996; Barth et al. 1996). Figure 1 shows one example, NGC 4579, in which the broad C IV line has FWHM = 6600 km s^{-1}, comparable to the linewidths seen in classical, luminous Seyfert 1s.

The LINER 1s that have been studied in detail almost invariably show very clear AGN-like properties, such as compact flat-spectrum radio cores and compact hard X-ray sources (Ho 2002). Their spectral energy distributions show that the central engines are broad-band emitters similar in many respects to luminous AGN, albeit with some clear systematic differences that suggest a different structure for the central engine (see Ho, this volume). The accumulated evidence leaves essentially no doubt that LINER 1s are a category of accretion-powered AGNs. The status of the LINER 2s is less clear, however, and this is the focus of the unification question for LLAGNs.

A note on classification: Almost all broad-lined LLAGNs are classified as type 1.8–1.9 on the Osterbrock (1981) system, indicating that broad Hα is weakly but definitely visible, while broad Hβ is either extremely weak or not detected. X-ray observations of several type 1.8–1.9 LLAGNs have shown that most of these objects are not heavily obscured, so that we have a clear view of

the central engine. For example, the LINER 1.9 NGC 4579 has a low obscuring column of $N_H \approx 4 \times 10^{20}$ cm^{-2} (Terashima et al. 1998), consistent with the fact that broad lines are clearly seen in its UV spectrum. For such objects, the type 1.8–1.9 classification is primarily the result of starlight contamination, which dilutes the equivalent width of broad Hα and Hβ; many of these would probably be classified as type 1.5 if they were observed through a spectroscopic aperture small enough to exclude the surrounding starlight. On the other hand, some type 1.9 LLAGNs are very heavily obscured sources in which the BLR must be substantially or completely hidden from direct view. Well-known examples include NGC 4258 (Makishima et al. 1994) and NGC 1052 (Guainazzi & Antonelli 1999; Weaver et al. 1999); in such objects the faint broad-line emission may be seen in reflected light.

Thus, the optical classification of LLAGNs into decimal subtypes is by itself not a good indicator of the degree of obscuration of the nucleus; it appears to be a function of starlight dilution in some objects, but obscuration in others. Some caution is warranted if LLAGNs of type 1.8–1.9 are included with higher-luminosity type 1.8–1.9 Seyferts in statistical studies of X-ray absorption or other properties (e.g., Risaliti, Maiolino, & Salvati 1999).

3. HST Imaging Surveys

High-resolution imaging of LINERs with *HST* has provide important constraints on the nature of the central engines and on the location and extent of obscuring material. UV imaging surveys by Maoz et al. (1995) and Barth et al. (1998) found nuclear UV emission (at ~ 2100 Å) in $\sim 25\%$ of the LINERs that were observed. About half appear pointlike at the resolution of *HST* and thus are good candidates for being genuine LLAGNs with nonstellar continua. Barth et al. (1998) showed that the low UV detection rate is primarily due to dust obscuration of the nuclei. The UV-dark LINERs are systematically found in higher-inclination host galaxies than the UV-detected LINERs, and the UV-detected galaxies also have lower reddening as measured from the Hα/Hβ ratio. This suggests that the predominant obscuring structures are foreground dust lanes that are preferentially aligned with the host galaxy disks. Similar 100-pc scale obscuring structures may be present in Seyfert galaxies as well (Maiolino & Rieke 1995; Malkan, Gorjian, & Tam 1998). Consistent with this hypothesis, *HST* V-band images revealed optically thick dust lanes in a substantial fraction of the sample galaxies, particularly in the UV-dark objects (Figure 2). Thus, the majority of LINERs probably do have UV sources in their nuclei (which could be either AGNs or young star clusters), but in most cases the UV source lies behind enough dust to render it invisible in a 1-orbit *HST* exposure.

Pogge et al. (2000) obtained *HST* narrow-band [O III] and Hα+[N II] images of 14 LINERs to study the narrow-line region (NLR) morphology and search for ionization cones like those found in some Seyfert 2 galaxies. A cone-like NLR morphology was found in only one object, NGC 1052, and possibly detected in another, M84. In general, the NLRs of LINERs appear irregular, with most objects showing clumpy knots and filaments, and overall there are no clear differences between type the NLRs of 1.9 and type 2 LINERs. Pogge et al. also examined broad-band color maps and unsharp-masked images to search for dust

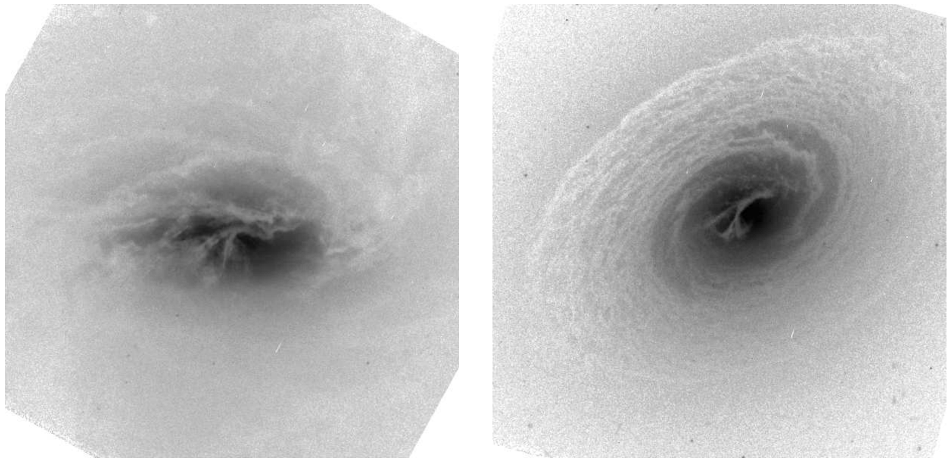

Figure 2. *HST* *V*-band images of dusty LINER 2 nuclei, from Barth et al. (1998). Pictured are the central regions of the S0 galaxies NGC 3166 (left) and NGC 3607 (right). Image size is $27'' \times 27''$.

lanes. Most of the UV-dark LINERs were found to have dust lanes in the immediate environment of the nucleus, further supporting the hypothesis that foreground dust plays an important role in blocking our view of the central engines.

4. Spectropolarimetry of LLAGNs

The discovery of a hidden BLR in polarized light in the spectrum of NGC 1068 (Antonucci & Miller 1985) was the key observation that proved that at least some Seyfert 2s are really Seyfert 1s in which the nuclear continuum and BLR are obscured. Following this discovery, a few groups attempted spectropolarimetric observations of LINERs, to test whether any LINER 2s contained hidden Type 1 nuclei and whether the broad Hα components in LINER 1s are seen in direct or scattered light. This proved to be an impossible task for 3–4 meter telescopes, as the overwhelming dominance of starlight in the optical spectra pushes any polarization signature to extremely low levels ($< 1\%$ in the continuum). At these low levels, it is difficult to discern whether any detected continuum polarization is due to scattering of nonstellar radiation, or instead merely the result of foreground dust in the host galaxy imprinting a polarization signature on the starlight spectrum.

Wilkes et al. (1995) were the first to successfully detect continuum and emission-line polarization from a LLAGN, the Seyfert 1.9 nucleus of NGC 4258. NGC 4258 is well known for the H_2O maser emission from its rotating, edge-on, circumnuclear disk that surrounds a 4×10^7 $M_\odot$ black hole (Miyoshi et al. 1995). The narrow emission lines are very strongly polarized ($1 - 10\%$), and the polarization vector of the emission lines and continuum is almost exactly parallel to the disk plane. The emission lines are broader in polarized light than in the total-flux spectrum, so scattering (rather than transmission through aligned

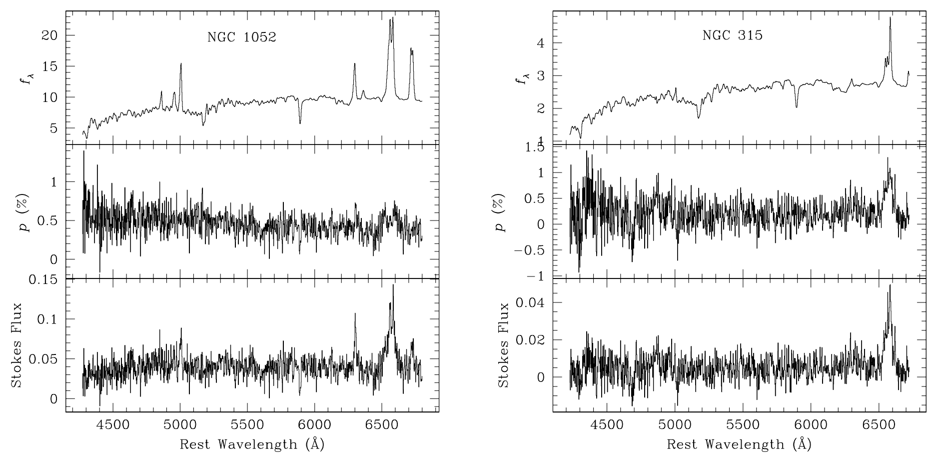

Figure 3. Spectropolarimetry data for the LINERs NGC 1052 and NGC 315, showing polarized broad components of Hα. Figures adapted from Barth et al. (1999b,c).

dust grains) is the most viable polarization mechanism, and provides a consistent explanation for the observed angle of polarization. The continuum polarization is only 0.2% because the nuclear spectrum is dominated by starlight, but imaging polarimetry showed that region emitting the polarized light is compact and centered on the nucleus. NGC 4258 is one of the few objects in which a clear connection can be made between polarized nuclear emission and the presence of an edge-on obscuring structure on subparsec scales. This provides an important confirmation of the Seyfert unification concept, and shows that the obscuring torus model can apply to objects with low luminosity.

A follow-up study by Barth et al. (1999a) found that the forbidden-line polarizations in NGC 4258 are correlated with the critical density of the lines, which can be explained if the disk or torus surrounds and obscures a substantial portion of a compact, density-stratified NLR. Thus, NGC 4258 appears to be a nearly unique case of a Seyfert 2 with a (partially) hidden NLR seen in scattered light. (Partially hidden NLRs have also been detected in some radio galaxies; see di Serego Alighieri et al. 1997.)

The only clear detections of polarized broad-line emission in nearby LINERs come from a small survey done at the Keck Observatory by Barth, Filippenko, & Moran (1999b,c). This survey targeted 14 LLAGNs, including LINERs and Seyferts with and without broad Hα. Broad Hα polarization was detected in 3 LINERs: NGC 1052, NGC 315, and (with less certainty) in NGC 4261. Curiously, these were the only ellipticals in the survey, and all three are known to have radio jets. In each case, the angle of polarization of Hα is nearly perpendicular to the jet direction, consistent with the obscuring torus scenario. The highest S/N data were obtained for NGC 1052; in this galaxy the Hα emission line has FWHM $\approx$ 5000 km s^{-1} in polarized light. NGC 4261 and NGC 315 are known to have dusty, 100-pc scale circumnuclear disks, and these are likely to be the outer extensions of the obscuring structures. Thus, at least *some* LINERs have obscuring geometries similar to those of Seyfert 2s with hidden BLR. It

is worth pointing out, however, that NGC 1052 and NGC 315 are classified as Type 1.9 objects, since their broad Hα emission was first detected in total-flux spectra.

Polarized emission lines have not yet been detected in any LLAGNs in spiral galaxies other than NGC 4258. There are two likely reasons. Most of the type 1 objects are probably seen directly rather than in scattered light, so no strong polarization is expected. Also, the *HST* surveys have shown that many of the type 2 nuclei lie behind a thick veil of foreground dust, and this larger-scale obscuring material would extinguish any polarized light from the nucleus even if there were an obscuring torus on parsec scales.

5. What are the Type 2 LINERs and Transition Objects?

The most important new data constraining the nature of LINER 2 and transition nuclei have come from recent surveys in the radio and X-rays; in these spectral regions it is possible to detect central engines that are completely obscured in the optical and UV. In a VLA survey, Nagar et al. (2000) find that 64% of LINER 1s and 36% of LINER 2s have compact radio cores; those with multifrequency data are found to be flat-spectrum sources. The undetected objects could still have radio cores which are intrinsically fainter, or undetected due to free-free absorption. This result sets a plausible lower limit to the fraction of genuine AGN central engines in LINER 2s. Those objects bright enough for VLBI observations at 5 GHz were studied by Falcke et al. (2000). All showed compact, high-brightness-temperature cores with $T_b \gtrsim 10^8$ K, confirming that an AGN rather than a starburst is responsible for the radio emission. On the other hand, Nagar et al. only detect a compact radio core in 1 out of 18 transition objects. Similarly, Filho et al. (2000) find a low (20%) detection rate of compact radio cores in a sample of 25 transition nuclei. The lack of radio cores in most transition objects does not prove that they are *not* AGNs, however. As Nagar et al. point out, LINERs show a correlation between radio power and [O I] luminosity, and transition objects have systematically lower [O I] luminosities than LINERs, so their radio sources are expected to be fainter.

X-ray observations provide another direct probe of the central engines. Using *ASCA* spectra, Terashima et al. (2000a,b) show that LINER 1s tend to follow the same correlation traced by higher-luminosity Seyferts between X-ray and Hα flux, supporting the interpretation of LINER 1s as photoionized AGNs. LINER 2s have systematically lower X-ray to Hα flux ratios, and Terashima et al. conclude that either they contain heavily obscured AGNs (with $N_H > 10^{23}$ cm^{-2}), or they are primarily powered by stellar processes. Similar conclusions have been reached by Roberts et al. (2001), using *ASCA* and *ROSAT* data. Since LINER 2s have very faint X-ray sources, which may be surrounded by diffuse emission or X-ray binaries of comparable brightness, observations at high spatial resolution are crucial if nuclear sources are to be detected. A *Chandra* survey of 24 LLAGNs by Ho et al. (2001) provides a dramatic new high-resolution view of nearby galactic nuclei. In this survey, all of the Type 1 LLAGNs were found to have nuclear point sources, and 4 out of 5 LINER 2s show compact nuclear emission as well. Consistent with the earlier ASCA results, however, the nuclear X-ray sources in LINER 2s are underluminous in comparison with LINER 1s

for a given Hα luminosity. Compact nuclear X-ray sources were found in only 2 out of 8 transition nuclei. The overall picture emerging from these observations is that the majority of LINER 2s are likely to contain AGNs, although their central engines may be intrinsically fainter than those of LINER 1s.

One slight twist on the possible LINER 1/2 unification is that there may be LINER 2 nuclei which are AGNs, but which do not contain obscured Type 1 nuclei. It is possible to find at least a few nearby LLAGNs which show no broad Hα emission lines in the highest-quality spectra available, but which also appear to be largely unobscured based on measurements of the X-ray absorbing column or observations of the optical/UV featureless continuum. NGC 4594, the Sombrero galaxy, is a good example (Nicholson et al. 1998); another may be M87, which is a LINER 2 (Ho et al. 1997b) that is not hidden behind an obscuring torus (Whysong & Antonucci 2001). These two galaxies have very massive black holes ($\gtrsim 10^9 M_\odot$) and both are extremely sub-Eddington accretors, with $\lesssim 10^{-5} L_{\rm Edd}$ (Ho 1999). It is tempting to speculate that at extremely low $\dot{m}$, the BLR fades dramatically or even ceases to exist altogether; this could be due to a shortage of gas, or the weakness of the ionizing UV continuum, or a change in the structure of the accretion flow. Such "naked Type 2" objects would be preferentially detected in early-type galaxies with very massive black holes because an AGN with $L < 10^{-5} L_{\rm Edd}$ would be extremely faint in a spiral galaxy having $M_{\rm BH} < 10^8 M_\odot$.

Another possibility is that some LINER 2s may be "fossil" AGNs in which the ionizing continuum of a Type 1 LINER has very recently turned off. High-excitation lines such as [O III] would decay in a timescale of a few decades while the decay time for lower-excitation species such as [O I] and [N II] would be roughly an order of magnitude longer (Eracleous, Livio, & Binette 1995). Maiolino (2000) has suggested, along these same lines, that some LINER 2s may be fossils of bright Seyferts. There must be some objects in the universe which fit this description, but they probably amount to only a tiny fraction of the LINER 2 population since the NLR fades so rapidly, and because LINER 2s are far more numerous than either LINER 1s or bright Seyferts. Also, in this scenario the fading [O III]-emitting region in LINER 2s should appear as a bubble or shell around the nucleus, and the *HST* imaging survey by Pogge et al. (2000) found no examples of such morphology.

The simplest explanation for the emission-line spectra of transition nuclei is that they are composite objects in which a LINER is surrounded by star-forming regions (Ho et al. 1993). In a ground-based aperture, their spectra would be a mix of AGN and H II region emission, accounting for the weakness of [O I] and other low-ionization lines. This scenario also accounts well for the Hubble type distribution of transition nuclei, which is intermediate between LINERs (which have a preference for early-type hosts) and H II nuclei (most commonly found in Sbc-Sd galaxies). In such composite systems, high-resolution spectroscopy can be useful for disentangling the contributions of the individual components (Gonçalves et al. 1999). However, this interpretation is challenged by the recent surveys cited above, because compact AGN-like radio and X-ray cores are found in only a small fraction of transition nuclei. The lack of any clear indication of AGN emission in most transition nuclei is a sufficient reason to consider alternative models for their power source; it would be dangerous

to assume that all transition nuclei contain AGNs simply because their optical spectra do not resemble normal H II regions. Similar considerations apply to at least part of the LINER 2 population, because a significant minority of them still lack conspicuous signs of an AGN central engine. Furthermore, the few existing UV spectra of LINER 2s and transition nuclei generally show that the UV continuum arises from young stars, not an AGN (Maoz et al. 1998).

Along these lines, a variety of models have been proposed to explain the properties of LINERs and transition objects solely on the basis of stellar phenomena. The main challenge for such models is to explain how the ionized gas surrounding a population of hot stars would emit enhanced levels of low-ionization forbidden lines, such as [O I] λ6300, in comparison with the spectra of normal H II regions. Space limitations preclude a complete discussion of these models so only a brief listing will be given. These include models based on photoionization by hot stars, including O stars with $T_{\rm eff} \gtrsim 45,000$ K (Filippenko & Terlevich 1992; Shields 1992); photoionization by young starbursts containing Wolf-Rayet stars (Barth & Shields 2000); and photoionization by an aging starburst combined with shock heating from supernova remnants (Engelbracht et al. 1998; Alonso-Herrero et al. 2000). Each of these models can readily reproduce transition-type optical line ratios, but each is also subject to potentially serious caveats and it is unlikely that any one of them can explain the entire transition-object population. LINER spectra can be reproduced with some difficulty (i.e., by pushing the stellar effective temperature or nebular density very high), and it is probably fair to conclude that these starburst-based models are more likely to apply to transition objects than "pure" LINERs.

Finally, LINER-like emission in ellipticals and spiral bulges can also be powered by ionizing photons from an evolved stellar population. Binette et al. (1994) demonstrated that post-AGB stars in ellipticals will produce a dilute, hard ionizing radiation field that should result in a LINER spectrum in the surrounding gas. The expected Hα equivalent widths are of order 1 Å, similar to the levels observed near the centers of many early-type galaxy bulges. Planetary nebula nuclei may also contribute to this effect (Taniguchi et al. 2000). Thus, galaxies without either an AGN or very recent star formation could still be classified as LINERs or transition nuclei provided that there is sufficient diffuse gas in the nuclear regions to be detected.

6. Conclusions

Traditional unification models based on the orientation of an optically thick obscuring torus apparently do apply to at least some fraction of the LLAGN population, as shown by a few detections of emission-line polarization, ionization cones, and heavily obscured X-ray sources. These detections constitute a small minority of the Type 2 LLAGN population, however. Obscuration on the scale of the host galaxy plays a more important role in affecting our view of the central regions of LINERs, at least in the UV and optical.

The larger question is whether Type 2 LLAGNs contain genuine AGN-like central engines at all. Radio and X-ray surveys suggest that the answer is "yes" for many, and perhaps most, LINER 2s. From the results of their *Chandra* survey, Ho et al. (2001) estimate that at least 60% of all LINERs

contain AGNs, but this result is still based on very small-number statistics. Further observations with *Chandra* will be the best way to improve on this estimate and complete the census of nearby AGNs, both by surveying larger samples and by obtaining deeper exposures to search for obscured or intrinsically very faint sources. Transition objects as a class present the weakest case for being members of the AGN family, and their spectra may instead be a manifestation of star formation in the extreme environment of galaxy centers.

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